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ABSTRACT

This paper applies Cognitive Flexibility Theory (CFT) principles to a 19th century Portuguese novel ("Cousin Basilio" by Eca de Queiros) that is available on the World Wide Web. An undergraduate Portuguese literature Web course that studied the novel is also described. Students' reactions to this distance learning course were analyzed by focusing on: users' characteristics (computer literacy, learning preferences, and motivation to participate in this study); users' opinions about the Web document; users' opinions about the structure of the Web course on distance learning; and users' opinions about the inclusion of courses on the Web during their undergraduate studies and for lifelong learning. (Contains 11 references.) (MES)

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COMPLEX KNOWLEDGE REPRESENTATION IN A WEB COURSE

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Abstract - Complex knowledge acquisition and transfer to new situations is always a difficult task to achieve. Cognitive Flexibility Theory principles are appropriate for complex domains and advanced knowledge acquisition. We apply CFT principles to a novel that is available on the World Wide Web. A Web course was conceived and is described on this paper. The reported research focuses on users' motivation to participate in this study, their comments about the analysis proposed to the novel and to the web course, and their opinion about web courses for further learning.

Introduction

Learning the introduction to a subject matter is not a difficult task, however, when we need to learn in depth about a particular knowledge domain, some difficulties arise due to conceptual complexity and increased ill-structuredness. Cognitive Flexibility Theory outlines a theory of learning and instruction for advanced knowledge acquisition in complex and ill-structured domains (Spiro et al., 1987, 1988, 1991a; 1991b; Spiro e Jehng, 1990). By ill-structuredness, Spiro et al. (1988) mean that many concepts interact contextually in a case and that their combination patterns are inconsistent across different case applications of the same type. Moreover, they mention that even where well-structured knowledge is involved, the context of its application is frequently ill-structured (Spiro et al., 1987). According to this statement, the ill-structuredness is an inherent characteristic of complex knowledge domain.

Advanced knowledge acquisition is the learning phase which follows the introductory one and it implies a deep understanding of content complexity. The learner must reason with it, and apply it flexibly in different contexts (Spiro et al., 1988). Thus, compartmentalizing knowledge, presenting clear instances, employing reproductive memory criteria, overreliance on a single basis for mental representation, on "top-down" processing, on context-independent conceptual representation, on precompiled knowledge structures, on rigid compartimentalization of knowledge components, and on passive transmission of knowledge all reduce important aspects of the complexity and are often in conflict with advanced knowledge learning (Spiro et al., 1988; Feltovich et al., 1993). Three major types of deficiencies in learning complex knowledge are widely recognized: misconceptions and incorrect knowledge, the inability to flexibly apply knowledge in new situations, and the lack of retention of knowledge that was previously acquired (Feltovich et al., 1993). New perspectives on instruction and assessment are required if education is to promote a deep understanding of complex and difficult subject matter. Cognitive Flexibility Theory emphasises the importance of successive presentations of the same material in rearranged instructional sequences and from different conceptual perspectives (Spiro e Jehng, 1990). To promote the mastery of complex knowledge and the ability to transfer that knowledge to new situations, Spiro et al. (1988) recommend several principles: avoidance of oversimplification and overregularization, multiple representations such as concepts and thematic perspectives, centrality of cases, conceptual knowledge as knowledge in use, schema assembly (from rigidity to flexibility), non-compartimentalization of concepts and cases (multiple interconnectedness), active participation, tutorial guidance and adjunct support for the management of complexity. A case represents specific knowledge pertaining to a context and it teaches a useful lesson when it exemplifies a new way of doing something or a new effect that is likely to be useful in later reasoning (Kolodner & Leake, 1996). Cases can come in many different shapes and sizes, covering large or small time slices (Spiro & Jehng, 1990; Kolodner & Leake, 1996). Cases need to be decomposed and represented along many partially overlapping dimensions, i.e., the same information must be represented in lots of different ways and many connections must be drawn across the decomposed cases, thus establishing many possible routes for future assembly (Spiro et al., 1987).

This theory generalises Wittgenstein's metaphor of the criss-crossed landscape (Spiro and Jehng, 1990). By criss-crossing conceptual landscapes the learner acquires interconnected knowledge structures that permit greater flexibility indispensable to apply knowledge to new situations. Flexible learning environments allow the same items of knowledge to be presented and learned in a variety of different ways and for a variety of different purposes.

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Applying Cognitive Flexibility Theory to the novel "Cousin Basilio"

As the CFT is case-based, the first priority is to define or choose the *cases*. "Cousin Basilio" is a 19th century novel written by Eça de Queirós, a nineteen-century Portuguese author. We proceed to divide the novel into five cases. Each case has several small texts or *mini-cases* (tab. 1).

Chapters	Cases	Mini-cases	Novel Context	19th century Context	Thematic Commentaries
I - III	I	8	8	3	37
IV - V	II	7	7	4	37
VI - VII	III	6	6	4	35
VII - XIII	IV	9	9	5	36
XIV - XVI	V	4	4	2	15
Total	-	34	34	14	160

Table 1 – Components of the process of deconstruction of "Cousin Basilio" according to CFT

Each mini-case has to be decomposed or deconstructed according to several *themes*. We select nine themes that help the learner to attain a deeper understanding of the novel. Then, for each mini-case we select pertinent themes (from the nine themes) and a *thematic commentary* for each applied theme is written. Each commentary explains how that general theme applies to that particular mini-case. One hundred and sixty thematic commentaries' in all are written (tab. 1). Flexibility in applying knowledge depends on cases being disassembled so that they may later be adaptively reassembled (Spiro et al., 1987).

Consequently, criss-cross planning from case to case is important. "The notion of 'criss-crossing' from case to case in many directions, with many thematic dimensions serving as routes of traversal, is central to our theory" (Spiro et al., 1987: 187). The same content material is covered in different ways, at different times, in order to demonstrate the potential flexibility of use in that content (Spiro et al., 1988). This *thematic criss-crossing* is pre-defined to the user. A theme or a combination of themes is selected and the user is conducted through the mini-cases and thematic commentaries, acquiring a deeper understanding of the novel. "By criss-crossing topical/conceptual landscapes, highly interconnected, web-like knowledge structures are built that permit greater flexibility in the ways that knowledge can potentially be assembled for use in comprehension of problem solving" (Spiro & Jehng, 1990).

Spiro et al. (1987) suggest a cyclical alternation between thematic criss-crossing (in which cases illustrate or concretise the abstractions) and cases (in which the same abstractions are used in a combined form to describe the cases).

"Cousin Basilio" – Web site design

"Cousin Basilio: multiple thematic criss-crossings" is available on the web (on the following URL: http://www.iep.uminho.pt/primobasilio). The design of this document was directed by two main ideas, one related to CFT principles and the other to the recreation of the 19th century atmosphere in the web pages (Carvalho, 1999).

The web site is divided into three main areas (fig. 1): Menu1 and Main1, Menu2 and Main2, and Footer. Menu1 is the main menu, on the left-hand side, and on the right-hand side the content selected on the main menu, usually presents texts from the novel (fig. 2). Menu2 is the second menu which is a dynamic one and depends on the option selected on the main menu. On the main2 one can access the information selected on menu2 (fig. 2).

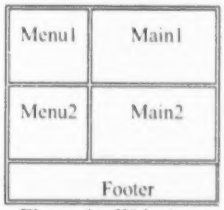

Figure 1 – Web site areas

In the Footer area, the user has the possibility to write his/her own Notes (click on the black pen), or to "Quit" the document (click on the three coins), and so on.

By accessing this document one finds an ancient book, which is interactive. By proceeding to Help (Ajuda) one may obtain information about the options available on both menus. All user information and instructions appear in blue, by means of a well-designed handwriting. Lastly, one is invited to write one's own name and password (this document is access free, however, the password is needed to save one's own Notes).

Figure 2 - Mini-case (main1) and Thematic commentary (main2)

The main menu (menu1) is always available with the following options: Cases, Oriented Thematic Criss-Crossings, Free Thematic Criss-Crossings (in which the user can search for cases and themes) and Table of Contents. The selected option on the main menu appears in red. On the main1, the texts of the novel have, as background, a light yellow page that resembles old stationery.

On the second menu (menu2) one is presented with the option to choose *Picture* or *Video* (which helps to recreate that particular time), one has also the option *Context* (the "Novel Context" gives information about the novel and the "19th century Context" gives information about some words related to furniture, transports, places, writers, operas, songs, and so on, that can be difficult for a 20th century student), *Thematic Commentaries* (which explain how each theme applies to that particular mini-case), *Themes* (a general description of each of the nine themes selected for analysing the novel), and *References* (authors already mentioned in "thematic commentaries" or in the general description of the Themes). The main2 background is blue (this resembles old official Portuguese stationery) and the text is sealed as a symbol of authenticity (fig.2).

Research Study

In previous research, we evaluated the Cognitive Flexibility Theory with regards to the importance of "Thematic Commentaries" and of "Oriented Thematic Criss-Crossings" on knowledge transfer to new situations (Carvalho & Dias, 1997; Carvalho, 1999). Results illustrated the importance of Thematic Commentaries on learning, i.e., the importance of the deconstruction process.

According to the results obtained (Carvalho & Dias, 1997; Carvalho, 1999), we may conclude that the document content and structure really help students to learn and to transfer knowledge to new situations. Consequently our present research focus is not on learning and knowledge transfer but on the users' characteristics, and on their reactions to the web document as well as to the structure of the course on distance learning.

Carvalho & Dias (1997) and Carvalho (1999) realised that autonomous learners enjoyed the challenge of constructing the answer to a given topic (like those of "Oriented Thematic Criss-Crossings", but this path was not available), by reflecting on the information available on the document. Thus, in this research we challenge the students, after visiting a "Case" and an "Oriented Thematic Criss-Crossing", to try to construct their thematic commentaries to the themes applied to a mini-case and to select the appropriate mini-cases to define a "traversal" through the novel, according to the topic presented at the "Oriented Thematic Criss-Crossing". After each one of these exercises, they are invited to check our paths. If learners accept this challenge they may get deeply involved and they may attain a better comprehension of the subject matter.

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Considering that further education is more and more demanding, we intend to analyse the subjects' reaction to this distance learning course by focusing on:

a) users' characteristics (computer literacy, Learning Preferences, motivation to participate in this study) and resultant implications on their opinions related to the following items:

b) users' opinions about the web document;

c) users' opinions about the structure of the web course on distance learning;

d) users' opinions about the inclusion of courses on the web during their undergraduate studies and for lifelong learning.

Course Structure and Pre-Requisites

As it is for advanced knowledge acquisition, this distance learning course on the Web establishes a pre-requisite with regards to the subjects' background: they have to be Portuguese literature undergraduate students or teachers of Portuguese literature.

They have to read the novel (450 pages) and to complete the tasks presented in the first package (see table 2). This first package includes a letter explaining the course structure, contacts, a "Learning Preferences Scale" (Carvalho 1998 & 1999) [1], a Questionnaire about subjects' computer literacy, and the pre-test.

Before starting the study			**Study and following sessions**		
Read the novel (450 p.)	**Package 1** letter	Session 0	**Package 2** Letter	**Package 3** letter	Report
	"Learning Prefer ences Scale"		Guidelines for sessions	Guidelines for sessions	
	Pre-test		Test	Post-test	
	uestionnaire on Comput literacy		Questionnaire of Opinion	Questionnaire of Opinion	

Table 2. Tasks to be achieved before, during, and after the course

After finishing the first package, subjects are asked to contact the researcher and to participate in a joint session (session 0, tab. 2), to be held in a computer laboratory at the university. The aim of this session is to help them feel comfortable to use and explore the web document. The subjects can contact the researcher by e-mail or by telephone at any time. It is not compulsory to send an e-mail, but it is recommended if they feel like sharing some ideas or raising some doubts.

At the end of session 0, they receive the second package which includes students' e-mail addresses, some guidelines for the following sessions, a knowledge test, and a Questionnaire of Opinion about the Web document.

The third package contains a letter with some explanations, indications for the sessions, a post-test, and a Questionnaire of Opinion. Finally, when they finish this study on the web, they have to write a report commenting on several aspects such as document design, the course structure, the quantity and the quality of the information available on the packages, and their opinions about courses on the web for university study and for further education.

We respected the pace and rythm of each subject; they started this study in April and the deadline to finish it was the 30th of June. Each time they submitted the content of a package, they received a new package.

Sample Characterisation

Nineteen 3rd year undergraduate students enrolled in Portuguese literature participated in this study, one male and eighteen females, volunteers, ranging from twenty to twenty nine years (the mode was 20 years and the mean was 22.5 years).

According to the information collected by the Questionnaire on Computer Literacy, only two subjects had never used a computer, all the others use it, but not often. Most of them had never explored an interactive environment such as CD-I (89.4%), CD-ROM (78.9%), or hypermedia (94.7%). Only six subjects (31.5%) had explored the Internet.

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[1] The "Learning Preferences Scale" has three dimensions: 'complex knowledge acquisition', 'autonomy in learning', and 'preference for complex knowledge'. This scale was developed based on the "Epistemological Learning Preference Instrument" (Jacobson, 1990), on the research of Schommer (1990, 1993), and of Jehng et al. (1993). The scale has been validated and data is available on Carvalho [1998 & 1999] (F1: alpha=0.83; F2: alpha=0.73; F3: alpha=0.63; the scale has a Cronbach's alpha =0.81).

Their attitude towards the computer was analysed according to two parameters: attitude (like, do not like, avoid) and feelings (comfortable, a little nervous, nervous), which are highly correlated (.71). Most of them (thirteen subjects), "like" to work with a computer, four subjects "don't like" and two "avoid" it. Fifteen subjects feel comfortable when they interact with a computer, two feel "a little nervous" and two feel "nervous".

Most subjects (15) feel comfortable when working with a computer, and eleven of them like to work with it, but four do not. The two subjects that feel "a little bit nervous" when they need to use a computer "like" to use it. Finally, the two subjects that feel nervous when using a computer "avoid" using it, but they neverthless accepted to participate in this research.

The results of the "Learning Preferences Scale" show that these subjects have a positive attitude[2] in all three dimensions. According to these results, subjects share the principles of Cognitive Flexibility Theory towards the acquisition of complex knowledge. With regards to the other dimensions, no one has a negative attitude, however, some have an indefinite attitude: five subjects in the second dimension "autonomy in learning" and eight subjects in the third dimension "preference for complex knowledge".

Subjects mention different kinds of motivation to participate in this study and several subjects (ten) refer to more than one motive. The most referred motive is to participate in a Web course on distance learning (fifteen subjects), the second one focuses on their interest in literary work (seven subjects), and the third one points out their interest in Eça de Queirós' literary work (five subjects).

Results and Discussion

The subjects did a pre-test before session 0 and a post-test after finishing the exploration of the web document. As the number of subjects was small (19), non-parametrics tests had to be used and the accepted significant level was alpha =.05. Tests were scored from zero to twenty. The mean obtained in the pre-test was 5.99 and the mean in the the post-test was 11.74. Subjects learned significantly from the pre-test to the post-test, p=.0002, according to Wilcoxon signed-rank test (Z corrected for ties: -3.724).

Users opinions about the web document

Several aspects were asked concerning the web document, such as, facility in learning how to use it, orientation in the document, path preference, involvement experienced, themes selected, influence of the document structure on learning, and its interface design.

Eleven subjects considered the web document "accessible to learn how to use" and eight subjects considered it "easy". During this study, they were asked three times about their *orientation* in the web document.

On the first session, 11 subjects felt comfortable, seven were disoriented, and one did not answer. On the following sessions[3], they improved their orientation. We think that this result can be explained by the acquired experience in the web document during sessions.

When asked about their path preference on the web document, the majority of subjects (57.8%), stated that they preferred the path "Cases", along all sessions. Surprisingly, 20% of subjects mentioned that they preferred all paths because "all of them are very appealing. All of them are important!"

They considered this study on the web "interesting" or "pleasant", and no one marked it as boring or frustrating, on the Questionnaire of Opinion. They felt actively involved in this study, both intellectually and physically (94.7%). Only one subject mentioned that she had been involved in a passive activity.

The selection of "Themes" has been indicated as adequate by all subjects, except one who considered it partially adequate. The reading proposed to the novel has been approved, sixteen subjects considered it "interesting" and three subjects found it "acceptable".

They considered that the structure of the document facilitates the comprehension of the novel (84.2%). They liked the web document interface, particularly the cohesion on the pages design recreating the 19th century. "The use of sealed stamps on a blue background as authentic text information, the black pen to write the notes, the coins, and the ancient book on the home site help to recreate a romantic and nostalgic atmosphere, that enhance the characteristics of the novel "Cousin Basilio". Theses details are more than just an ornament, they emphasise the ambience of the last years of the 19th century".

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[2] The attitude is positive if 3.5 and 5, the attitude is indefinite if 2.5 and 3.5, and the attitude is negative if 1 and 2.5 [Carvalho, 1998 & 1999]. The Likert's scale used has 5 points.

[3] At the end of package 2, 16 subjects felt comfortable, 2 were disoriented, and 1 didn't answer. At the end of the study, 18 subjects felt comfortable and only one felt disoriented.

Users' opinions about the structure of the course on distance learning

Twelve subjects (two had never used a computer) reported that session 0, where the researcher explained the function of all options and paths, was indispensable. Seven subjects considered that the information available on "Help" (Ajuda) is clear enough to explore the document easily.

All guidelines and tasks to be achieved were considered appropriate and clear. "The table [on the guidelines sheet for the session] to be completed on each session about visited mini-cases, contexts, and thematic commentaries helps greatly on the document exploration".

Subjects were invited both to construct the possible explanations of the applied themes to each text in the path "Cases" and to select the texts that support a given "Topic" as mentioned previously. Only four subjects accepted this challenge during all sessions, although ten subjects accepted it the first time it was suggested. Eight subjects argued that they didn't have enough time to do it. Some of the subjects who accepted that challenge said that "it promotes a deeper study", another one mentioned that she "realised that, when trying to explain *thematic commentaries*, some of her ideas were wrong, but others only needed to be completed". The majority of subjects that accepted this challenge had a positive attitude towards "autonomy in learning" of the "Learning Preferences Scale".

Some mentioned that a few times the access to the web was very slow and they felt that it was boring to wait for the links.

Users' opinions about other courses on the web during their undergraduate studies and for lifelong learning

All users positively accepted the idea of having documents like "Cousin Basilio" on the web, as a support to their learning modules in the university.

They also had a very favourable opinion about courses like this one on the web for lifelong learning (74%). When asked about their preference for (i) distance learning on the web or (ii) a mixed course that works partially in a room with students and teacher (particularly at the beginning, when everybody knows each other and learns how to use the web course information) and partially on the web. Some subjects preferred to do everything through the web (26%), others did not answer this question (11%), but the majority of the subjects preferred a combination of face-to-face meetings and distance learning on the web (63%).

Conclusion

Although the subjects' computer literacy was low, they felt it was easy to use the web document and to navigate on it. In order to achieve such favourable opinion as they reported, particular attention was given to the session zero in the laboratory, to help all users with different backgrounds to feel comfortable with the structure of the web document.

Only a few subjects accepted the challenge to build their own knowledge and then to verify it. However, the majority of those subjects that accepted the challenge have a positive attitude towards the "autonomy in learning" of the "Learning Preferences Scale".

The users liked the web document design and structure, and they considered this study pleasant. They accepted in a positive manner the idea of having documents like this one to support their modules at the university. They were also receptive to the idea of being enrolled in distance learning on the web for further learning. However, the majority of learners preferred a combination of a face-to-face meetings and distance learning on the web.

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